A NOTE ON INCENTIVE FEE CONTRACTING

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The purpose of this note is to indicate some difficulties which arise when the incentive fee concept is applied to subcontractors.

Some incentive fee contracts apply the concept only to cost but sometimes it is broadened to include other factors such as weight, timeliness, and reliability.

For example, we consider a hypothetical incentive fee contract for a missile which provides the following target objects and relative sharing factors.

Target cost	C_t	=	\$100,000,000.	, $S_C = .5$
Target time	T_t	=	50 weeks	, $S_T = .2$
Target weight	W_t	=	100,000 pounds	, $S_W = .1$
Target Reliability	R_t	=	.90	, $S_R = .2$

and a target profit P_t of \$10,000,000. Suppose that the total profit P is given by the formula

$$(1) \qquad P = P_t + A_C + A_T + A_W + A_R$$

where the A's are the adjustment terms for the several factors and are given by

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(2) $$A_C = \frac{1}{4}(C_t - C)$$

(3) $$A_T = \begin{cases} 0.2(T_t - T)\times 10^6 & \text{if } 50 \geq T \geq T_t \\ 0.05(T_t - T)\times 10^6 & \text{if } 40 \leq T \leq T_t \\ 0.5 \times 10^6 & T \leq 40 \end{cases} .$$

Time over 50 is not acceptable.

(4) $$A_W = \begin{cases} .5 \times 10^6 & \text{if } W < 90{,}000 \\ 50(W_T - W) & \text{if } 90{,}000 \leq W \leq W_T \\ 100(W_T - W) & \text{if } W_T \leq W \leq 110{,}000 \end{cases} .$$

Weight over 110,000 is not acceptable.

(5) $$A_R = 2(R - R_T)\times 10^5 \text{ if } .80 \leq R \leq 1.00$$

Reliability under .80 is not acceptable and over 1.00 is not possible.

Here C, T, W, R are actual cost, time, weight, and reliability. Note that deviations above and below a given target specification need not have the same sharing coefficient.

Next, suppose that the missile is to be assembled from ten components each of which is to be manufactured under a subcontract. We ask if there is a reasonable way in which to extend the incentive fee concept to the subcontracts. Suppose for simplicity that each subcontract has a target price of \$8,000,000. One procedure would involve using a formula in the form of (1) for each subcontractor with P_t replaced by $P_t' = .08P_t$, C_t replaced by $C_t' = .08\, C_t$, scaling by a factor of .08 plus other adjustments in the terms A_T and A_R, and with a scaling for A_W which also takes into account the target weights of the components.

Such a procedure would not seem to be unreasonable for A_C', since an increase in cost by one subcontractor could be compensated by a cost

saving by another subcontractor.

The situation for A'_W is somewhat similar although here the arrangement is stacked in favor of the prime contractor in the following way. Suppose that all weights are at target value except that one subcontractor is 500 pounds over and a second one is 500 pounds under target weight, then $A_W = 0$, $A'_W = -100\text{x}500$ and $A''_W = 50\text{x}500$. Thus the prime contractor nets a profit of \$25,000 just from these deviations.

The situation for time is more tricky. Suppose that one subcontractor is ten weeks late; then his penalty is $A'_T = -.2 \times 10 \times 10^6 \times .08 = -\$160{,}000$. Suppose that each of the remaining subcontractors is ten weeks early; then the prime contractor pays them in toto $9 \times .05 \times 10 \times 10^5 \times .08 =$ \$360,000. Now since all components must be on hand before assembly, the prime contractor's performance is limited by the poorest of the subcontractors so in this case his time summand is: $A_T = -.2 \times 10 \times 10^6 =$ -2,000,000. The final result is a net loss of \$2,200,000. to the prime contractor.

If the reliability measure behaves like a probability and if the ten components have independent failure probabilities then ten subassemblies each with reliability .9 would give an overall reliability $(.9)^{10}$ which is less than .45. The minimum reliability requirements on components must then be jacked up to $.978 = (.8)^{1/10}$ just to assure an acceptable assembly. A reasonable subcontractor target reliability would be $.989 = (.9)^{1/10}$ and the incentive summand would be:

$$(6) \qquad A'_R = (R' - .989) \times \frac{160{,}000}{.011} \text{ if } .978 \leq R' \leq 1.000.$$

(Here R' = 1.000 gives an incentive award of \$160,000. = .08 x \$2,000,000.)

Of course the reliability measure R need not be assumed to operate like a probability. It might depend say on mean time to failure, in which case the non-compensatory feature of the time summand is again encountered.

This simple example is not based directly on any actual prime contract although each of its features has appeared in actual contracts. The situation pictured by this example is obviously an oversimplification

but it should serve to point out several important features that should be considered when extending the incentive fee concept to subcontracts:

(a) If individual components have a strictly addititive effect on the total project then the incentive fee concept can be safely extended to subcontractors although as illustrated in the weight case this may lead to some minor inequities.

(b) If the performance of the total project is measured by that of the poorest of the components then one must beware of substantial magnification effects as noted in our discussion of the time effect.

(c) If the performances of the components combine like independent probabilities to determine overall performance the range of variability for individual components is severely restricted.